Quarterly Progress Report #2

Reporting Period: April 1, 2006 – June 30, 2006

Experimental Assessment of Aggregate Surfacing Materials

MDT Project No. 8117-30, MSU Project No. 4W0839

Submitted by:

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Task 1: Project Management/Administration

Project work was initiated on January 11, 2006 with an internal kick-off meeting at Montana State University (MSU) to review the project tasks and goals, and to discuss the types and quantities of aggregates that would be necessary to conduct the suite of proposed laboratory tests. Progress Report No. 1 was submitted in April 2006, at the completion of the first quarter.

During this quarter, Dr. Mokwa and Mr. Cuelho oversaw the various tasks associated with the project through frequent meetings with one another and the project graduate research assistant (Nick Trimble).

Task 2: Laboratory Testing

As discussed below, laboratory testing continued on the following three standard aggregate types:

1. CBC Type A Grade 5 – designated in this project as CBC 5A-1 through CBC 5A-5,
2. CBC Type A Grade 6 – designated in this project as: CBC 6A-1 through CBC 6A-5, and
3. CTS Type A Grade 2 – designated in this project as CTS 2A-1 through CTS 2A-5.

Working in conjunction with personnel from the MDT Materials Department, requests were sent to MDT District offices to obtain the relatively large aggregate samples (400 to 500 lb each) that are necessary to conduct the lab tests. Based on conversations that we have had with Matt Strizich, the distribution of test samples has been changed from the original plan. Based on the revised test plan, we have now received all of the 14 sample types necessary to complete the testing program, as shown in Table 1. We greatly appreciate the assistance provided by MDT personnel in obtaining and delivering these samples. The updated sample distribution plan is as follows:

- 6 – CBC 6A samples
- 3 – CBC 5A samples, and
- 5 – CTS 2A samples.

Table 1 includes a summary of the sample origins, designations, locations and other relevant information that was included on the data sheets transmitted with the samples.

Table 2 summarizes the laboratory testing program and shows the quantity of tests completed as of June 30, 2006. This table will be continually updated during the study as a means of charting the progress of laboratory testing. Updated versions of the table will be provided in subsequent progress reports. In summary, laboratory related activities conducted during this quarter include:

- Direct shear, LA abrasion, and particle size testing. About 90 % of these tests are complete on all samples.
- Approximately 50 % of the maximum and minimum void ratio testing is complete, as shown in Table 2. Samples marked as 0.5 out of 1 still require saturated minimum void ratio tests.
- 100 % of the modified Proctor testing has been completed or omitted (see explanation below).
- The large 10-in-diamter permeameters have been set up and calibrated. Permeability testing using these permeameters will commence during the third quarter.

Based on the testing conducted to date, we have observed that the modified Proctor test is not the best test to use on crushed base course materials for this research project because of the free-draining characteristics of the material. These processed materials contain few fines and have relatively large particle sizes. Consequently, it is difficult to reliably determine an optimum water content and maximum dry density using the Proctor impact test procedures. Instead, the maximum and minimum void ratio tests (ASTM D4253 and ASTM D4254, respectively) will be used to obtain a measure of the relative density of the samples. Relative density measurements will be used as the metric of control for determining the degree of compaction of the remolded samples that will be used in the direct shear and permeability tests. Incidentally, it has been the authors' experience that many earthwork construction specifications require the max/min void ratio test in lieu of the Proctor impact test whenever a soil sample contains less than about 10 to 12 percent fines. The samples we are testing all contain considerably less than 10% fines.

The primary reason for conducting laboratory compaction tests on this project is to obtain a metric for judging the relative density of compacted samples used in direct shear and permeability testing. The maximum and minimum void ration tests are recognized in the industry as the preferable laboratory tests for determining the relative density of cohesionless soils using the following equation:

$$D_r = \frac{e_{\max} - e}{e_{\max} - e_{\min}} \times 100\% \qquad (1)$$

where, D_r = relative density, e_{max} = maximum laboratory determined void ratio (corresponds to minimum density), e_{min} = minimum laboratory determined void ratio (corresponds to maximum density), and e = void ratio of prepared sample.

Equation 2 represents a more convenient form of the expression for D_r because we typically measure density in the lab instead of void ratio. (Void ratios are readily converted to values of

density using phase relationships.) Relative density in terms of measured laboratory density is calculated as follows:

$$D_r = \frac{\rho_{max}(\rho - \rho_{min})}{\rho(\rho_{max} - \rho_{min})} \times 100\% \quad (2)$$

where ρ_{max} = maximum laboratory determined density, ρ_{min} = minimum laboratory determined density, and ρ = density of prepared sample.

A literature search is underway to document similar permeability and shear strength studies that have been conducted on aggregates or base course materials.

Action Items for Next Quarter:

* Continue laboratory testing with a focus on conducting permeability tests.
* Examine and review published literature to document similar permeability and shear strength studies that have been conducted on aggregates or base course materials.

Task 3: Analyze and Synthesize Results

Data from laboratory tests are entered into spreadsheets and processed concurrently with the experimental work. Computed results are reviewed immediately for reasonableness. Synthesis of results will commence as soon as a critical mass of testing is complete.

Action Items for Next Quarter:

* Continue organizing and processing laboratory data.
* Begin synthesizing comparison test results from different aggregate samples.

Task 4: Report

Quarterly Progress Reports

Action Items for Next Quarter:

* Produce Progress Report #3 for the quarter encompassing July through September 2006

Final Report

Work on the final report will be initiated during later phases of the project.

TABLE 1. Sample Descriptions

Aggregate Type	MDT District	Borrow Name or Owner	Nearest Town	County	Section Location	*Approx. Amount	Date Received	Comments
CBC 6A-1	Great Falls	John Haynes	Great Falls	Pondera	S½: S3-T28N-R7W	8 bags	2/14/06	
CBC 6A-2	Billings	Empire S&G (Wilson Pit)	Billings	Yellowstone	E½: S6-T1N-R27E	8 bags	2/14/06	
CBC 6A-3	Glendive	BLM	Miles City	Dawson	NW¼, SE¼: S9-T15N-R48E	8 bags	2/14/06	North of Terry, MT
CBC 6A-4	Missoula	Richardson, Collin	Thompson Falls	Sanders	Tract 6&7: S14-T21N-R29W	6 bags	2/14/06	Weeksville-West
CBC 6A-5	Butte	Neil Hazel	Toston	Broadwater	SW¼: S23-T5N-R2E	8 bags	3/15/06	US 287 So. of Toston. Project # NH8-4(41)93
CBC 6A-6	Kalispell	Sandon Const.	Kalispell	Flathead	SW1/4: S36-T30N-R21W	8 bags	2/14/06	Commercial source
CBC 5A-1	Great Falls	Helena S&G	Helena	Lewis and Clark	SE¼, SW¼: S23-T10N-R3W	8 bags	2/14/06	
CBC 5A-2	Missoula	G. Ruffato	Stevensville	Ravalli	W1/2, NE1/4: S23-T11N-R20W	6 bags	2/14/06	North of Stevensville Wye-Florence
CBC 5A-3	Kalispell	JTL-Hodson Pit	Kalispell	Flathead	W1/2, NE1/4 & SW1/4, NE1/4: S23-T30N-T21W	8 bags	3/15/06	Local commercial source
CTS 2A-1	Havre	Peterson Pit	Devon	Toole	SW¼, NW ¼: S23-T30N-R2E	8 bags	2/14/06	
CTS 2A-2	Glendive	Fisher S&G	Glendive	Dawson	SW¼: S34-T16N-R54E	8 bags	2/14/06	
CTS 2A-3	Missoula	JTL	Missoula	Missoula	E1/2, SE1/4: S6-T13N-R19W	6 bags	2/14/06	
CTS 2A-4	Lewistown	Brevig Land & Live	Lewistown	Fergus	NW¼, SW¼: S21-T16N-R17E	8 bags	3/15/06	Casino Creek Concrete
CTS 2A-5	Billings	JTL	Billings	Yellowstone	SE¼, S½: S15-T1S-R25E	8 bags	3/15/06	

*Note: One bag ≅ 40 to 60 lb of material.

TABLE 2. Laboratory Testing Program Summary

Aggregate Type	Gradation	L. A. Abrasion	Modified Proctor	Direct Shear	Max/Min Voids	Permeability
(No. of tests to be performed)	(1)	(1)	(1)	(3)	(1)	(3)
CBC 6A-1	1	1	*	3	0.5	--
CBC 6A-2	1	1	*	3	0.5	--
CBC 6A-3	1	1	*	3	1	--
CBC 6A-4	1	1	1	3	0.5	--
CBC 6A-5	1	1	*	3	0.5	--
CBC 6A-6	1	1	*	3	0.5	--
CBC 5A-1	1	1	*	3	--	--
CBC 5A-2	1	--	*	--	--	--
CBC 5A-3	1	1	*	3	1	--
CTS 2A-1	1	1	1	3	0.5	--
CTS 2A-2	1	1	1	3	0.5	--
CTS 2A-3	1	--	1	3	0.5	--
CTS 2A-4	1	1	1	3	0.5	--
CTS 2A-5	1	1	1	3	1	--

Note: This table provides an accounting of the number of tests conducted to date. A "--" indicates the test was not conducted or has not been completed by the last day of the reporting quarter. A "*" indicates the test has been removed from the testing program.

Summary of Expenditures

Table 3 summarizes the expenditures on this project through June 30, 2006. Total dollar expenditures for the project through June 30, 2006 were $19,775.31, leaving $22,892.69 for the remainder of the project.

TABLE 3. Budget Summary

Budget Category	Budgeted Funds	Spent This Period	Total Spent	Total Remaining
Salaries	$17,848.00	$7,734.12	$7,938.21	$9,909.79
Benefits	$4,628.00	$1,537.22	$1,608.69	$3,019.31
In-State Travel	$150.00	$0.00	$0.00	$150.00
Out-of-State Travel	$0.00	$0.00	$0.00	$0.00
Expendable Supplies	$200.00	$37.43	$182.51	$17.49
Tuition	$0.00	$0.00	$0.00	$0.00
Subcontracts	$0.00	$0.00	$0.00	$0.00
MDT Direct Costs	$22,826.00	$9,308.77	$9,729.41	$13,096.59
Overhead	$4,566.00	$1,861.77	$1,945.90	$2,620.10
MDT Share	$27,392.00	$11,170.54	$11,675.31	$15,716.69
WTI/MSU Share	$15,276.00	$4,050.00	$8,100.00	$7,176.00
Total	$42,668.00	$15,220.54	$19,775.31	$22,892.69

Project Schedule Summary

An updated summary of the project schedule is shown in Figure 1. The project is ahead of schedule and the budget is on track with anticipated forecasts.

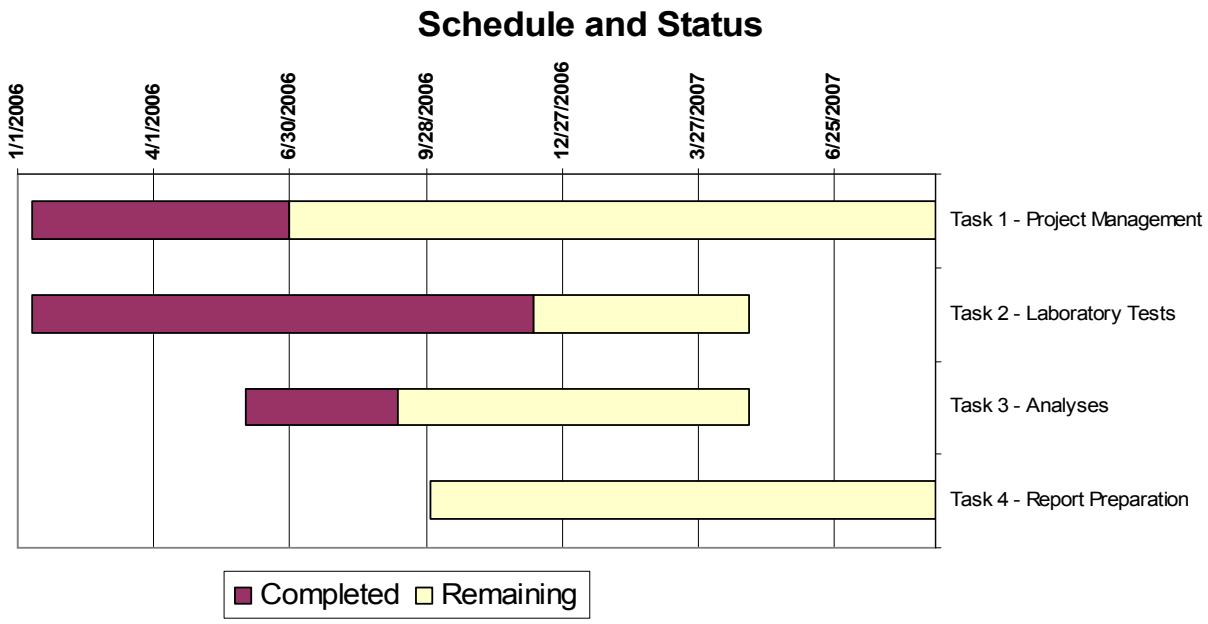

FIGURE 1. Project schedule summary.